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Heart Rots of Engelmann Spruce and Subalpine Fir in the Central Rocky Mountains

T. E. Hinds[1]

Engelmann spruce (*Picea engelmannii*)-subalpine fir (*Abies lasiocarpa*) forests are widely distributed in western North America—from the northern Rocky Mountains of British Columbia and Alberta southward into Arizona and New Mexico. They occur at elevations of 2,000 to 7,000 feet in their northern range whereas they are found from about 8,000 to 12,000 feet in the south. Heart-rot defect and the importance of specific fungi causing decay vary considerably over the range of the hosts. Average defect attributed to rot, for instance, amounts to 20 percent of the gross merchantable board-foot volume of spruce in Alberta, 12 percent in the Blue Mountains of Oregon and Washington, and 15 percent in Colorado.

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Although three decay fungi[2]—*Polyporus tomentosus* var. *circinatus*, *Phellinus pini* (=*Fomes pini*), and *Haematostereum sanguinolenta* (=*Stereum sanguinolentum*)—are common to most areas, their frequency of occurrence and the amount of defect they cause vary considerably.

[1] Plant pathologist, Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service. Maintained in cooperation with Colorado State University, Fort Collins, Colo.

[2] The taxonomy of various decay fungi is being revised; consequently, the presently accepted names are used in this leaflet with the old names in parentheses.

Table 1.—*Cull deductions as a percentage of gross tree volume*

Indicators	Age class	
	Under 250 yrs.	Over 250 yrs.
	Pct.	*Pct.*
Phellinus pini punk knots or sporophores	68	86
Broken top or dead top with adjacent dead rust brooms	21	25
Basal wounds, dead rust brooms or dead leader in living crown, frost cracks, forks (all types), trees joined at base to one another, spike top, or trunk wounds	8	11

This leaflet is concerned with the heart rots of Engelmann spruce and subalpine fir in the central portion of their range in the Rocky Mountains, where mixed spruce-fir stands grow at elevations of 9,000 to 11,500 feet.

How decay fungi affect these species, and the relationship of rot to site, age, and tree size are not completely understood. In spruce, certain tree abnormalities are indicative of trunk rot and are reliable cull indicators. Fir, on the other hand, has no consistent external indicators of rot, although the amount of decay generally increases with age and tree diameter.

Engelmann Spruce

Occurrence of Heart Rots

Estimates of stand defect due to heart rot in Colorado range from 7 to 26 percent. One means of estimating defect is based on average stand age and the average amount of cull associated with indicators (tree abnormalities) of rot. Cull deductions as a percentage of gross tree volume for three groups of indicators by two age classes are in table 1.

Rot Fungi Involved

The numerous fungi associated with indicators of rot differ not only in the amount of cull they produce, but also in the type of rot they cause. Two general types of wood rot are recognized: (1) white rot, in which the fungi initially destroy lignin and cellulose, leaving a fibrous or stringy residue; and (2) brown rot, in which the fungi destroy the cellulose and leave a dry, brown, cubical or crumbly mass of lignin constituents. Table 2 lists the major rot fungi of mature to overmature Engelmann spruce along with associated type and amount of rot common in Colorado.

Location in the Tree

Trunk rots, caused by fungi that decay the heartwood of living trees, account for about three-fourths of the rot loss in Engelmann spruce. The two

Table 2.—*Major rot fungi of mature to overmature Engelmann spruce and associated rot, Colorado*

Major rot fungi	Type of rot	Average amount of cull	Average length of rot column
		Board feet	*Linear feet*
Trunk rots			
Phellinus pini	White	190	35
Echinodontium sulcatum	White	150	24
Columnocystis abietina	Brown	100	30
Haematostereum sanguinolenta	White	80	21
Coriolellus serialis	Brown	50	16
Butt rots			
Phellinus nigrolimitatus	White	150	25
Pholiota alnicola	White	90	8
Coniophora puteana	Brown	70	9
Fomitopsis pinicola	Brown	70	15
Polyporus tomentosus var. *circinatus*	White	60	10

major ones are the white pocket rots, *Phellinus pini* and *Haematostereum sanguinolenta.* Red ring rot or white pocket rot attributed to *P. pini* is the most common of the two and causes extensive rot columns. It is associated with all rot indicators, including those found in the basal portion of a tree. The typical rot is easily recognized by its white pockets (fig. 1) and by its association with punk knots and sporophores which are common on trees with long standing heart rot.

Although the red heart rot of *H. sanguinolenta* is not as extensive within individual trees as *P. pini,* it occurs nearly as commonly and is also associated with most rot indicators. The affected wood is firm and is reddish brown at first, then turns light brown, dry, and friable in the advanced stage. White mycelial sheets are found in the rotted wood in longitudinal section. The

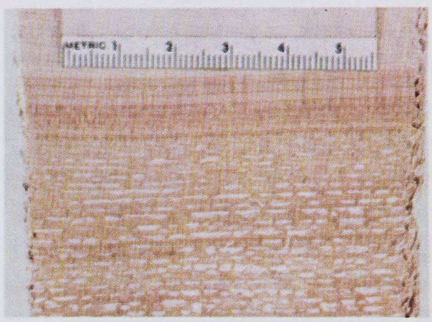

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Figure 1.—*Phellinus pini: Top,* shelflike conks (fruiting bodies) normally found on tree trunk; *bottom,* typical advanced white pocket rot.

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Figure 2.—***Echinodontium sulcatum: Top,*** **frost crack indicator of rot;** ***bottom,*** **cross section through frost crack area shows the associated trunk rot.**

thin, leathery, annual fruiting bodies, or sporophores, are seldom found on living trees. Length of rot column and cull caused by the yellow pocket rot of *Echinodontium sulcatum* (=*Stereum sulcatum*) (fig. 2) are greater than those of *H. sanguinolenta,* but this kind of rot occurs less frequently. Other white pocket trunk rots found infrequently are *Phellinus ferrugineofusca* (=*Poria ferrugineofusca Amylostereum chailletii* (=*Stereum chailletii),* and *Sistotrema raduloides* (=*Trechispora raduloides*).

The relatively uncommon brown trunk rots are usually associated with trunk wounds and broken tops. When associated with trunk wounds, they cause smaller losses and are frequently mixed with white rots which progress faster. Although *Columnocystis abietina* (=*Stereum abietinum*) causes the greatest volume loss per infection by brown trunk rot fungi, *Coriolellus serialis* (=*Trametes serialis)* is more common and causes a greater overall loss.

Some butt rot fungi, such as the common white stringy rot of *Pholiota alnicola* and the white pocket rot of *Polyporus tomentosus* (fig. 3), are known to gain entrance through roots. Although they can cause trunk rot upward to an average of 8 to 10 feet, their main damage is to the roots, which predisposes trees to windthrow. Most basal rot is associated with old basal wounds and frost cracks. The large white pocket rot of *Phellinus nigrolimitatus* (=*Fomes nigrolimitatus*) is usually considered to be a butt rot, but it is also associated with other trunk wounds, and causes considerable cull throughout the tree. Other white butt rots of some importance are *Gloeocystidiellum radiosum* (=*Corticium radiosum*), *Lentinel-*

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Figure 3.—*Polyporus tomentosus: Top,* mushroom-like fruiting bodies found on the ground at the base of a tree; *bottom,* cross section with typical decay pattern associated with old basal wound.

lus montanus, Armillariella mellea (=*Armillaria mellea*), and *Pholiota squarrosa.*

With the exception of *Coniophora puteana* and *Fomitopsis pinicola* (=*Fomes pinicola*), the brown rots seldom cause extensive basal decay. *C. puteana* is most frequently encountered, but *F. pinicola* is equally important in causing cull. Because *F. pinicola* usually attacks only dead sapwood, it is often associated with old, extensive basal wounds.

Subalpine Fir

Occurrence of Heart Rots

A major part of the spruce-fir forests in the central Rocky Mountains consists of overmature stands suggesting a climax type that has prevailed for many years. Many stands are unevenaged with large old-growth trees and an understory of younger trees in various stages of suppression. The dominant and codominant firs in these stands were often suppressed for many years by a spruce overstory which has since died.

There are marked relationships between rot, tree diameter, and age. Losses from rot range from less than 7 percent (board-foot basis) in trees under 10 inches in diameter to more than 40 percent in trees over 20 inches. Average rot volume in trees larger than 9.5 inches in diameter amounts to 35 percent on a board-foot basis. While broken tops and trunk wounds are usually indicative of extensive rot, consistent external indicators are lacking. Rot in trees younger than 100 years is negligible, but rot increases rapidly with increasing age to 35 percent in the 150 to 199 year age class. The amount of rot is extremely variable in older age classes.

Rot Fungi Involved

The important rot fungi of subalpine fir, type of rot, fre-

Table 3.—*Rot fungi of subalpine fir and associated type of rot, frequency of isolation from heart rot, and average cull*

Major rot fungi	Type of rot	Frequency of isolation	Average cull
		Percent	*Cubic Feet*
Trunk rots			
Haematostereum sanguinolenta	White	37	6.9
Phellinus pini	White	7	6.9
Amylostereum chailletii	White	7	2.5
Butt rots			
Gloeocystidiellum radiosum	White	10	0.1
Coniophora puteana	Brown	7	0.8
Armillariella mellea	White	7	0.8
Pholiota squarrosa	White	6	0.9
Coniophora olivacea	Brown	5	0.8
Polyporus tomentosus var. *circinatus*	White	3	1.1

quency of isolation from heart rot, and their associated cull are given in table 3.

Location in the Tree

Trunk rots account for about two-thirds of the overall total cull in subalpine fir. *Haematostereum sanguinolenta* (fig. 4) is the most important fungus and is responsible for at least 75 percent of the trunk rot volume. Called "red heart" because of its marked reddish color (see cover), the rot, nevertheless, can be confused in the field with that caused by *A. chailletii.* Infection occurs mainly through wounds and broken branches. Multiple trunk infections and extensive mixed rot columns are common. Fruiting bodies of the fungus are seldom found on living trees. When found, they are usually located on old scars. The fruiting bodies of this fungus redden or "bleed" when wounded—hence the common name "the bleeding Stereum."

Phellinus pini is the second most important fungus, accounting for about 15 percent of the trunk rot volume. The occurrence of the white stringy trunk rot caused by *A. chailletii* is as common as that of *P. pini,* but losses due to the organism are only about 5 percent of the total trunk rot.

Of the other trunk rot fungi, *Phellinus hartigii* (=*Fomes robustus* var. *tsugina*) may be the most important because it is parasitic. It invades the sapwood and kills the cambium. This suggests that some early mortality in subalpine fir stands may be due to this organism.

Although butt rots account for only about one-third of the total decay, they are thought to be of

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Figure 4.—*Hematostereum sanguinolenta:* The bleeding Stereum fruiting body found at an old wound.

major significance in the history of subalpine fir stands because they lead to windthrow. Nearly two-thirds of all basal infections enter through roots or basal wounds. Volume losses in windthrown trees weakened by root and butt rots are probably greater than those caused by these fungi in standing trees. The soft, spongy rot of *Armillariella mellea,* the white pocket rot of *Polyporus tomentosus,* and the white stringy rots of *Pholiota alnicola* and *P. squarrosa* cause about half of the butt rot volume losses. Their mushroom-like fruiting bodies are found on roots and at tree bases, but are not common enough to be useful indicators of decay. *Gloeocystidiellum radiosum* is the most common butt rot fungus in subalpine fir, but its yellow stringy rot causes only negligible amounts of cull.

Three species of *Coniophora* are the principal causes of brown cubical butt rot (fig. 5). They gain entrance through ba-

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Figure 5.—*Coniophora puteana: Left,* effused fruiting body on a piece of slash; *right,* typical advanced stage of brown cubical rot.

sal wounds; however, rot columns seldom extend 4 feet above ground. *Coniophora puteana* is the most common and causes the greater volume loss.

Minimizing Future Losses

Spruce-fir forests are the most productive timber type in the central Rocky Mountains. Also, they are important for water yields, wildlife habitat, recreation, and scenic value. As virgin stands are converted to managed stands, heart rots can be expected to decrease. Early removal of spruce, with known indicators of rot, and of fir in the older age classes will aid in establishing healthy, vigorous forests with a greater growth potential. Rot losses in future stands can be minimized by shorter cutting rotations—140 to 150 years for spruce, and 100 to 125 years for fir. Careful marking of individual trees to be cut and close supervision of logging operations to reduce mechanical injuries will minimize points of entry for decay fungi. Proper slash disposal will lower the inoculum potential of heart rot fungi in residual stands. These sanitation methods are important because direct control of heart rots is not yet possible.

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